Producing canopy height and understory cover maps for pine forests over a large region using heterogeneous lidar datasets

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Motivation: Why care about a tree height map for pines?

•It is important for estimation of pine forest biomass. Biomass maps (along with age) can also be used to validate process-based models such as 3PG.

•Canopy height (along with age) can be used to estimate site index, important for growth and yield models and the 3PG model.

•Canopy height and understory cover are critical for fuel load estimation, for forest fire models.

Methods

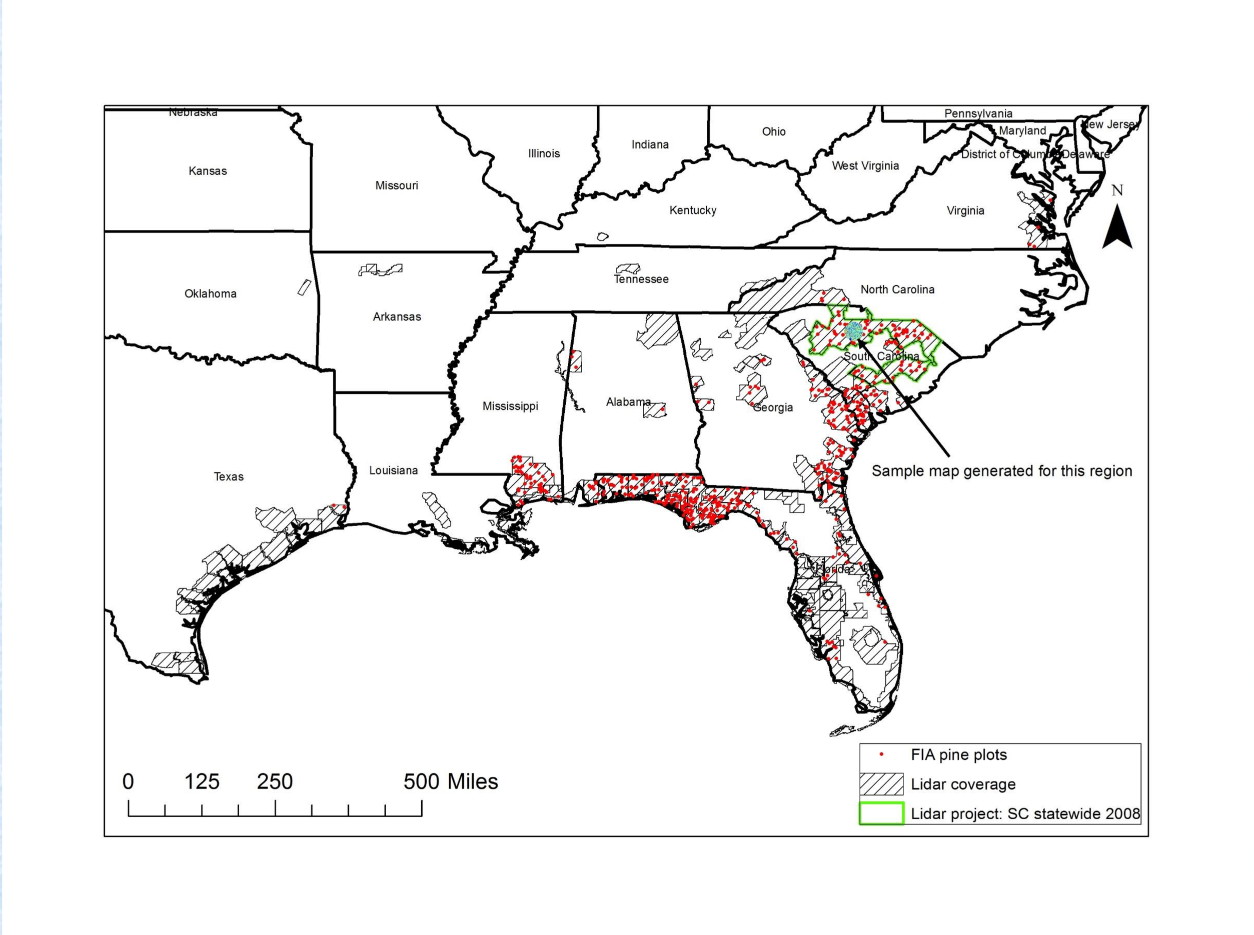

Figure 1: The lidar coverage, along with the location of FIA pine plots (plots where basal area of pine species is more than 95%).

- First, we acquired LIDAR data from USGS, NOAA and NRCS (AL) for a large area (figure 1), with LIDAR acquisition dates ranging from 2005 to 2011. Over 90 separate LIDAR projects are involved.

- **Canopy height:** we intersected this data with USFS forest inventory and analysis (FIA) plot location data. This gave us 523 pine plots (30 x 30 m) where we had both LIDAR and FIA field data (figure 1). Then, simple linear regression models between the LIDAR parameters and FIA field measurements of tree heights were made. The all-plots model used all available plots (n=523) while the homogeneous plots model used only the homogeneous plots (n=417).

- **Understory cover:** For field data, we have 49 FIA P3 plots where the "live shrub cover" (%) is measured. From the lidar data (120 x 120 m plots), we calculate the number of returns (all returns) in various height bins (see figure 2). One promising metric is understory lidar cover density (ULCD), calculated as the ratio of various height bins (see figure 3). We later use a random regression model to estimate this cover from various lidar metrics.

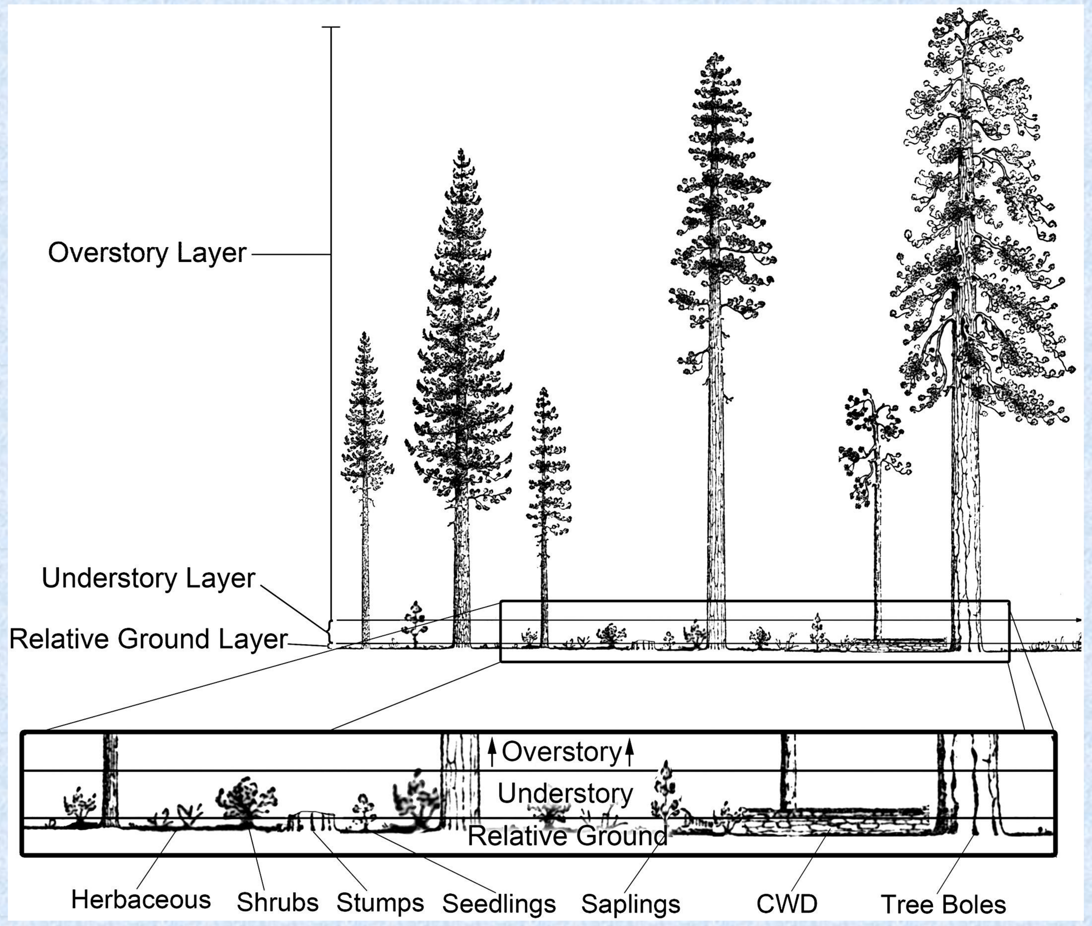

Figure 2: Depiction of a typical understory height bin, and possible components that lidar pulses can intersect. From Wing *et al* (2012).

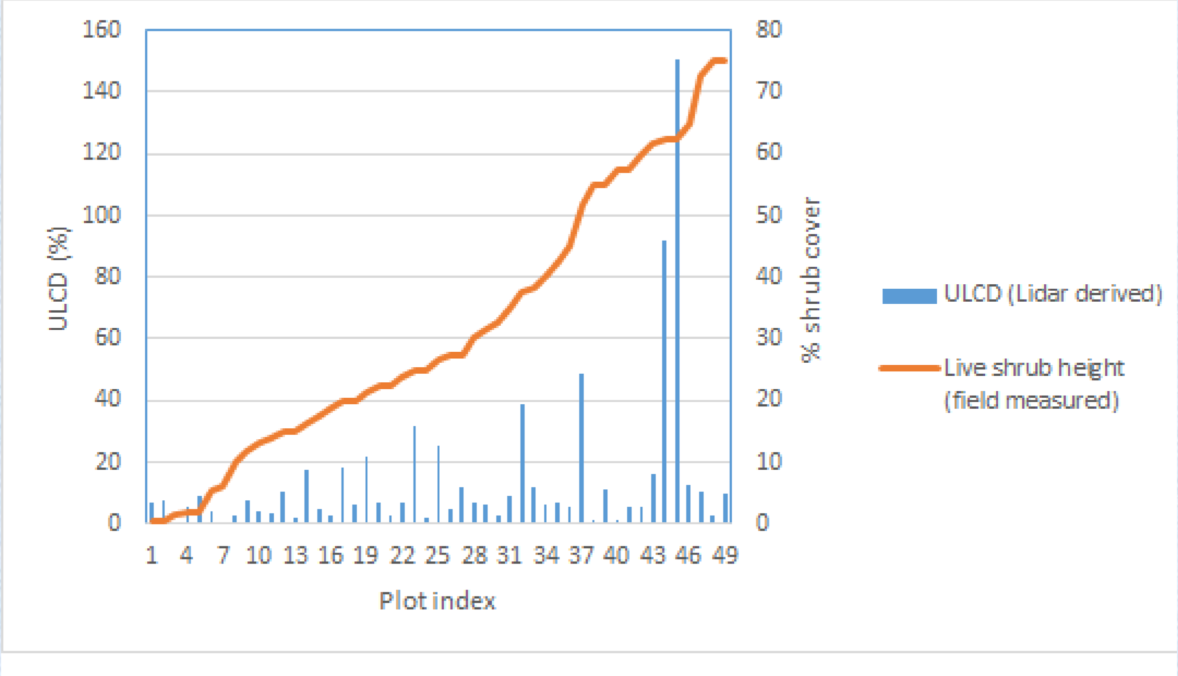

Figure 3: The variation of ULCD (defined as the percent of pulses in the 0.5 to 3.0 height bin to those in the 0 to 0.5 height bin) for increasing live shrub cover (n=49). ULCD, on the average, increases with increasing shrub cover. Further analysis with tier-II data can help in understanding the factors that affect the robustness of this metric.

Results

- All-plots model: RMSE = 3.2 meters (see figure 4).
- Homogeneous plots model: RMSE= 2.6 meters.
- We generated sample canopy height maps based on the all-plots model (figures 5 and 6).
- Random forest model to predict live shrub cover from lidar metrics: RMSE = ~20% (n=49). Sample ULCD map was also generated, which gives an indication of understory cover (figure 7).

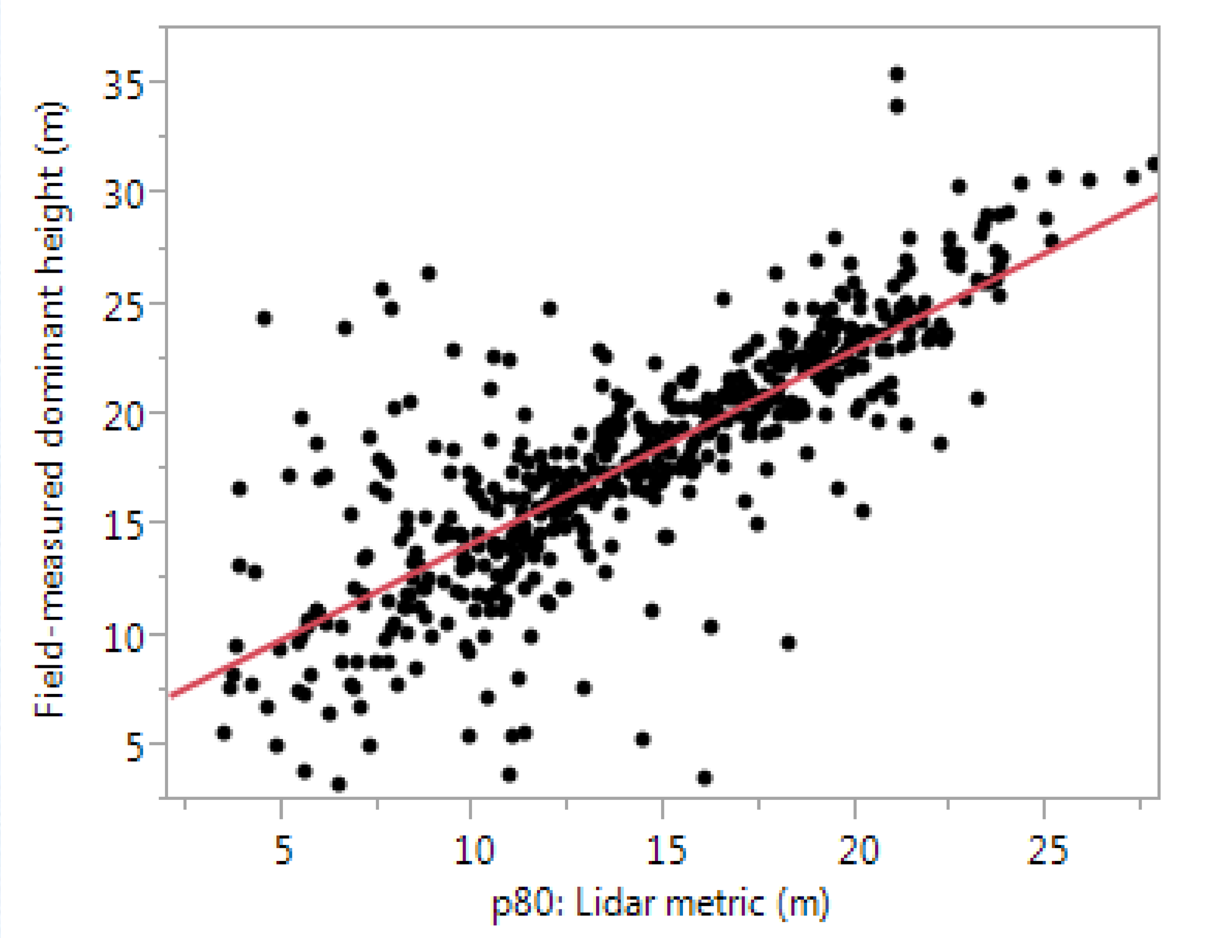

Figure 4: The 80th percentile of height above ground (p80) of lidar first returns shows good correlation with canopy height (n=523, RMSE = 3.2 m). The simple linear regression fit line is also shown.

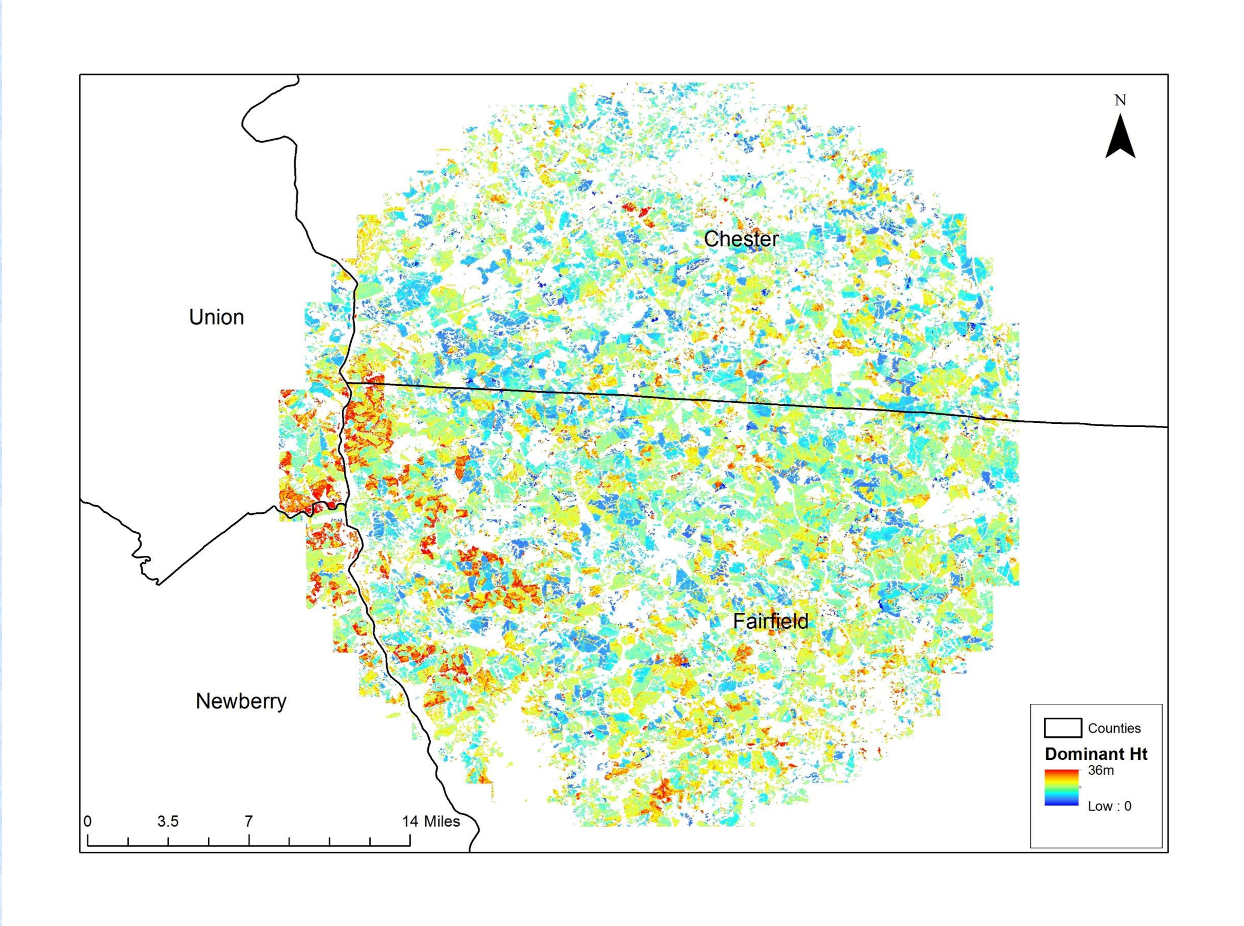

Figure 5: A sample canopy height map for pines, generated using the all-plots model. A reasonable variation of heights is seen over the landscape.

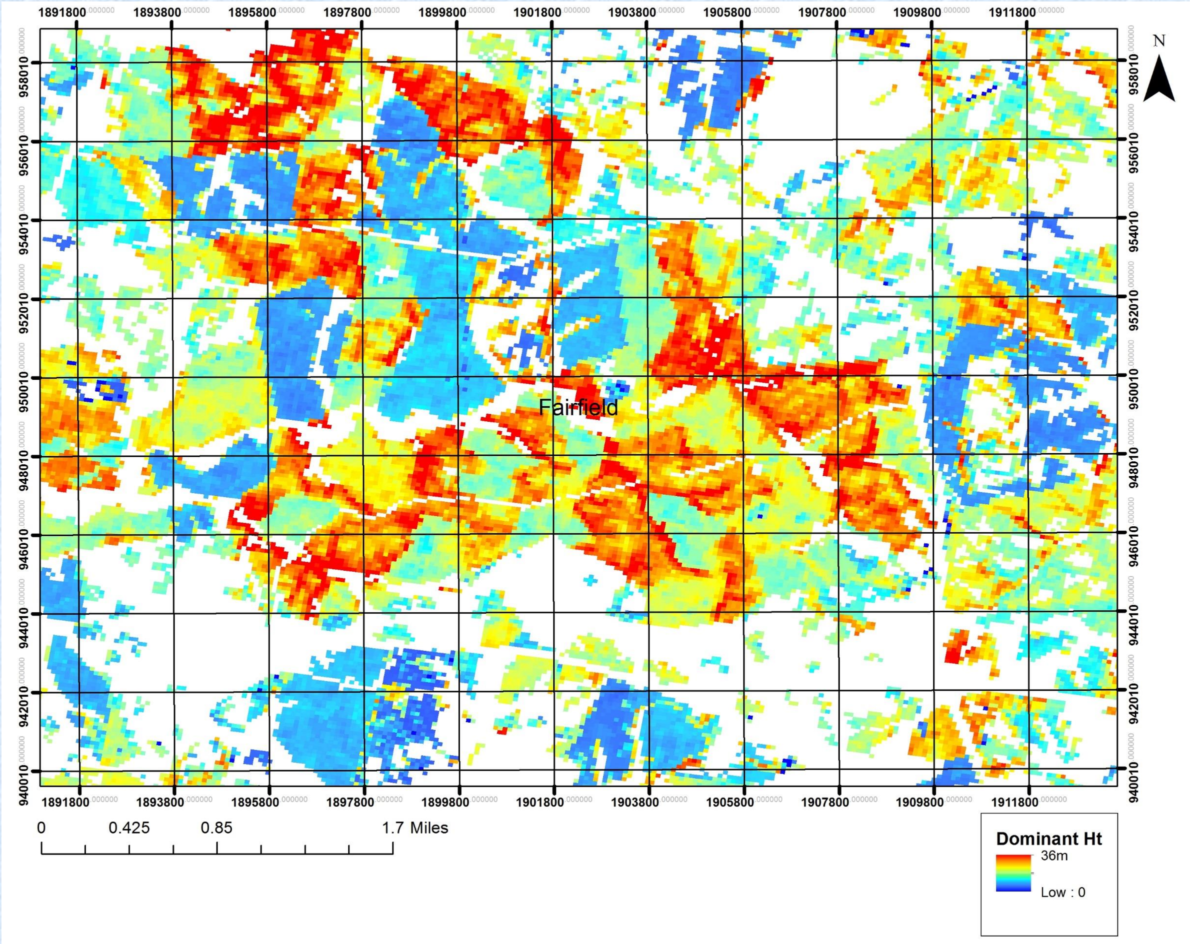

Figure 6: Same as figure 5, but zoomed in into a south-west part of the area.

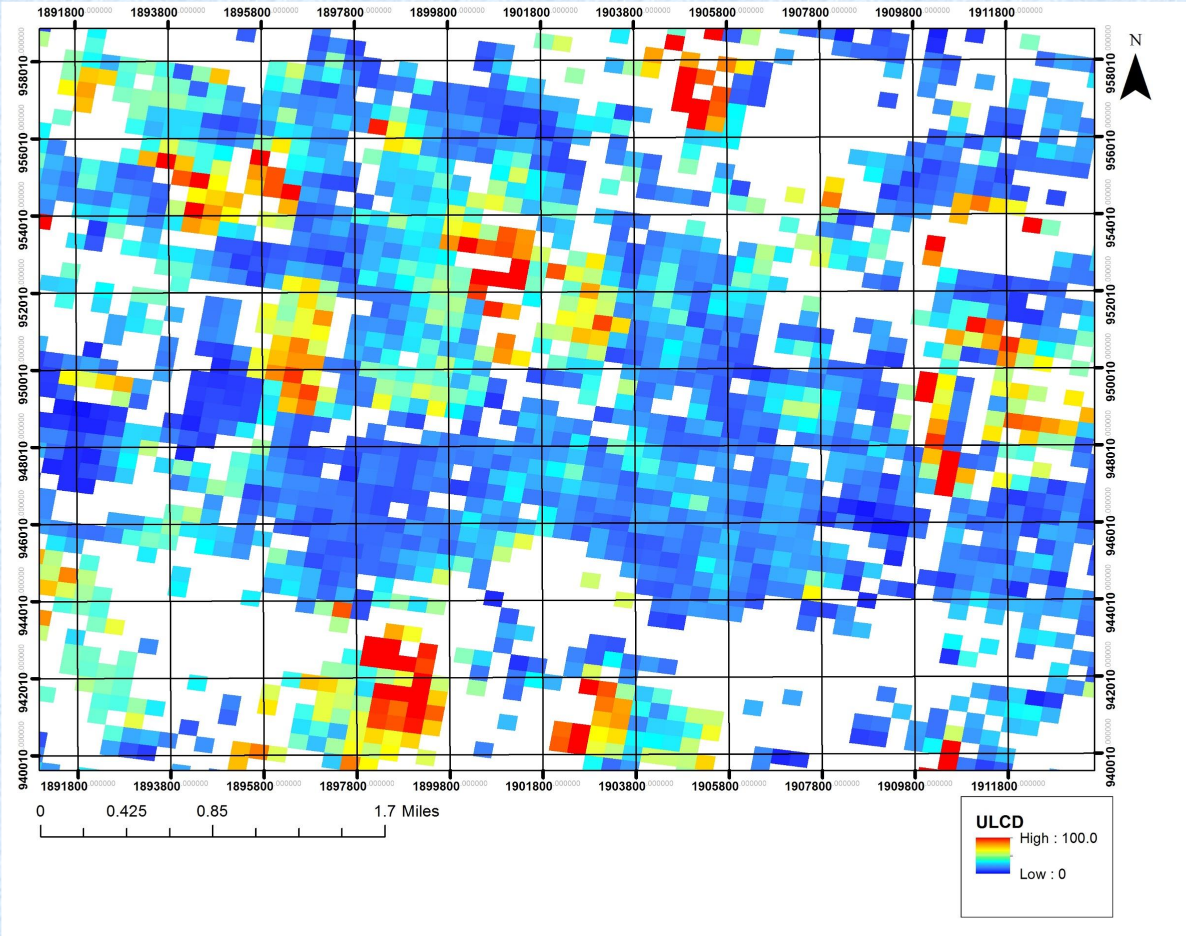

Figure 7: Variation of ULCD for the same parcel as figure 6.

Publications

- Ranjith Gopalakrishnan, Valerie A. Thomas, John W. Coulston and Randolph H. Wynne, "Generation of wall-to-wall canopy height maps using heterogeneous lidar datasets over a large region", In: Proceedings, American Society for Photogrammetry and Remote Sensing (ASPRS) Annual Conference (IGTF 2015), Tampa, USA. May 4-8, 2015.
- Gopalakrishnan, R., Thomas, V.A, Coulston, J., Wynne, R.H. 2013. Efficacy of using heterogeneous lidar datasets in predicting canopy heights over a large region. In: Proceedings, 13th International Conference on LiDAR Applications for Assessing Forest Ecosystems (SilviLaser 2013), Beijing, China, Oct. 2013, pp. 146-153.